Closed Orbit and Linear Optics Correction in the Ring

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Ring Closed Orbit Correction

- Form a Merit Function consisting of sum of squares of orbit deviations at all BPMs

$$f = (x_1^{\text{meas}} - x_1^{\text{model}})^2 + \ldots\ldots + (x_{44}^{\text{meas}} - x_{44}^{\text{model}})^2$$

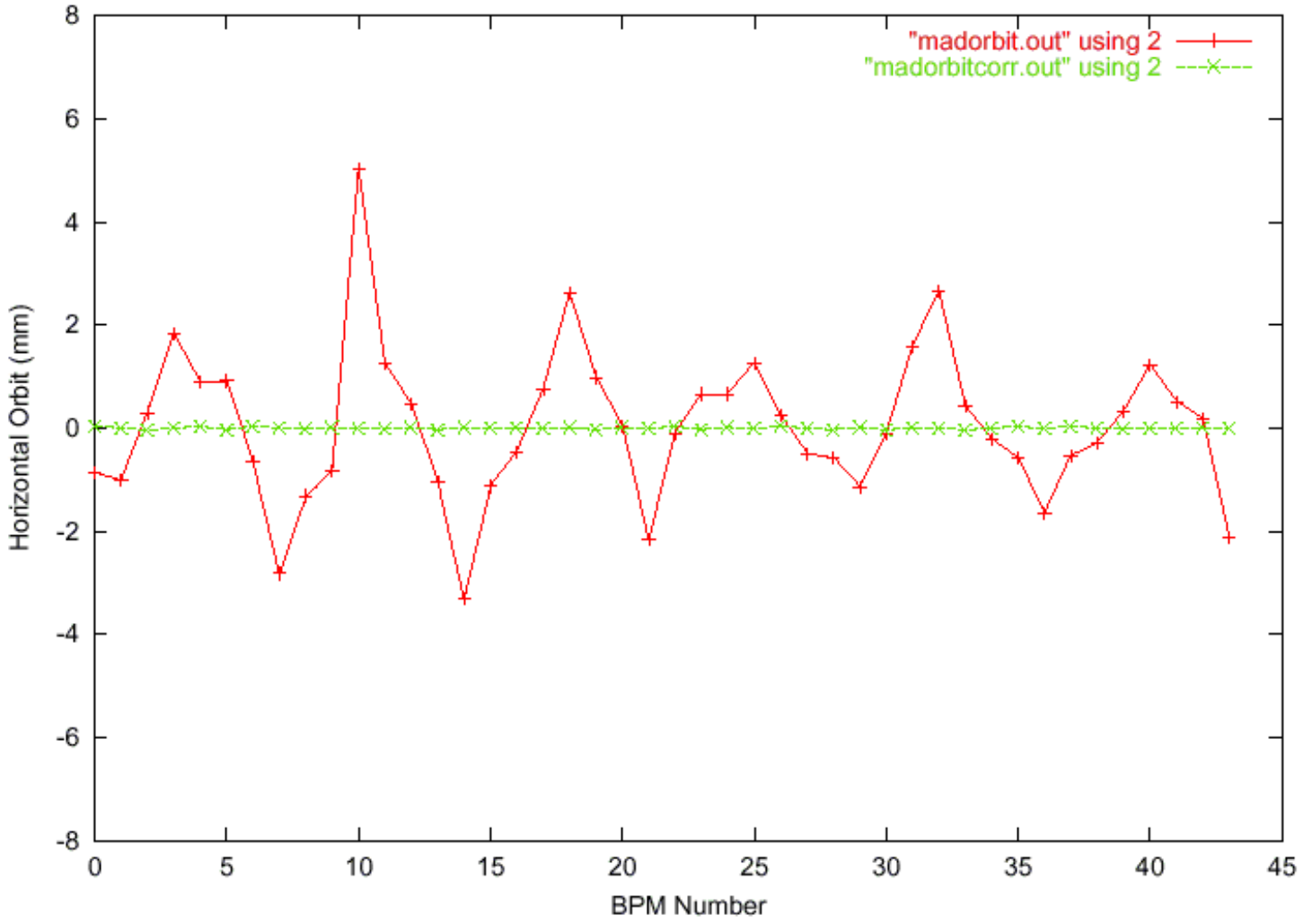
- Where $$x_i^{\text{model}} = \sum^{Correctors} R_{ij} q_j$$

$$R_{ij} = \text{response matrix}$$

$$q_j = \text{corrector kicks}$$

- A gradient-minimization algorithm (Numerical Recipes FRPRMN) adjusts the corrector strengths θ_j to minimize the merit function.

Closed Orbit Correction Example
100 micron random quad position errors



Linear Optics Correction

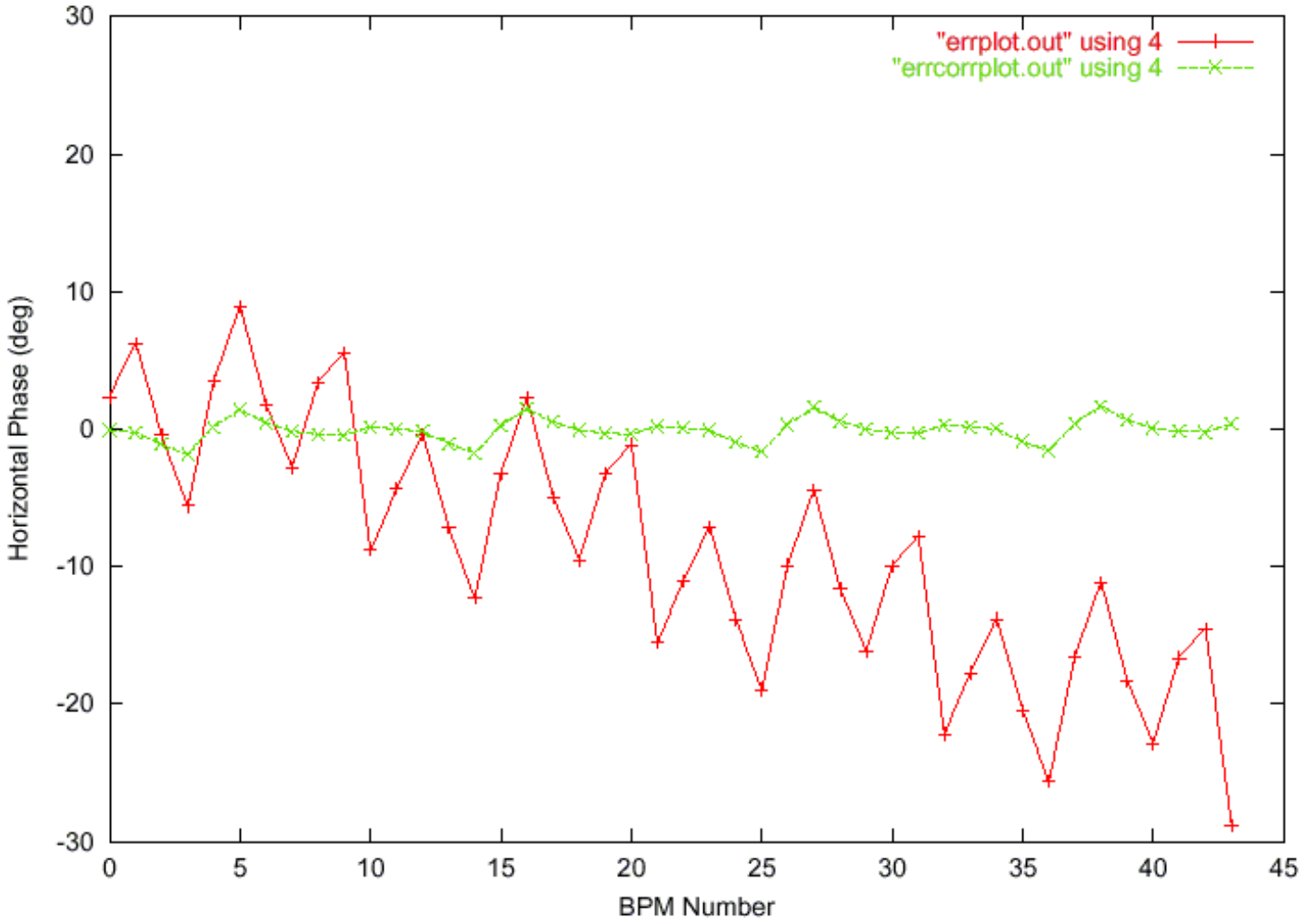
- Use the same general method as for closed-orbit correction
- Requires betatron-phase measurements at all BPMs
- Form a merit function consisting of sum-of-squares of betatron phase errors at all BPMs:

$$f = (f_1^{\mathrm{H,meas}} - f_1^{\mathrm{H,model}})^2 + (f_1^{\mathrm{V,meas}} - f_1^{\mathrm{V,model}})^2 +$$
$$\ldots\ldots + (f_{44}^{\mathrm{H,meas}} - f_{44}^{\mathrm{H,model}})^2 + (f_{44}^{\mathrm{V,meas}} - f_{44}^{\mathrm{V,model}})^2$$

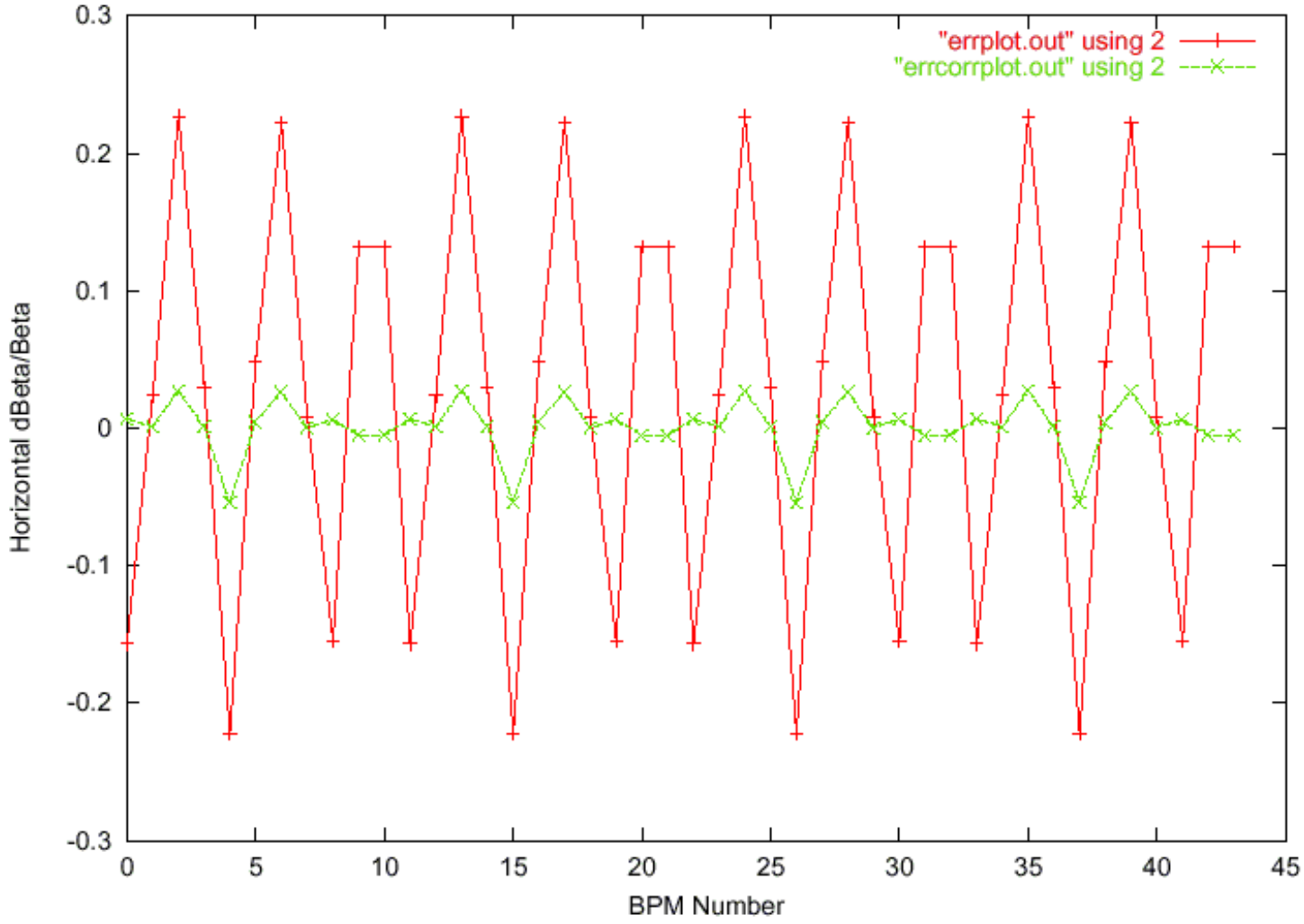
- The model phase is calculated from an optics model of the ring.
- The minimization routine adjusts the quadrupole supplies in order to minimize the merit function.
- Example – 1% random main quadrupole supply current errors (or equivalently, 1% systematic magnetic length errors)

Horizontal Betatron Phase Error (degrees)

$Df = f_{meas} - f_{design}$ vs. BPM Number

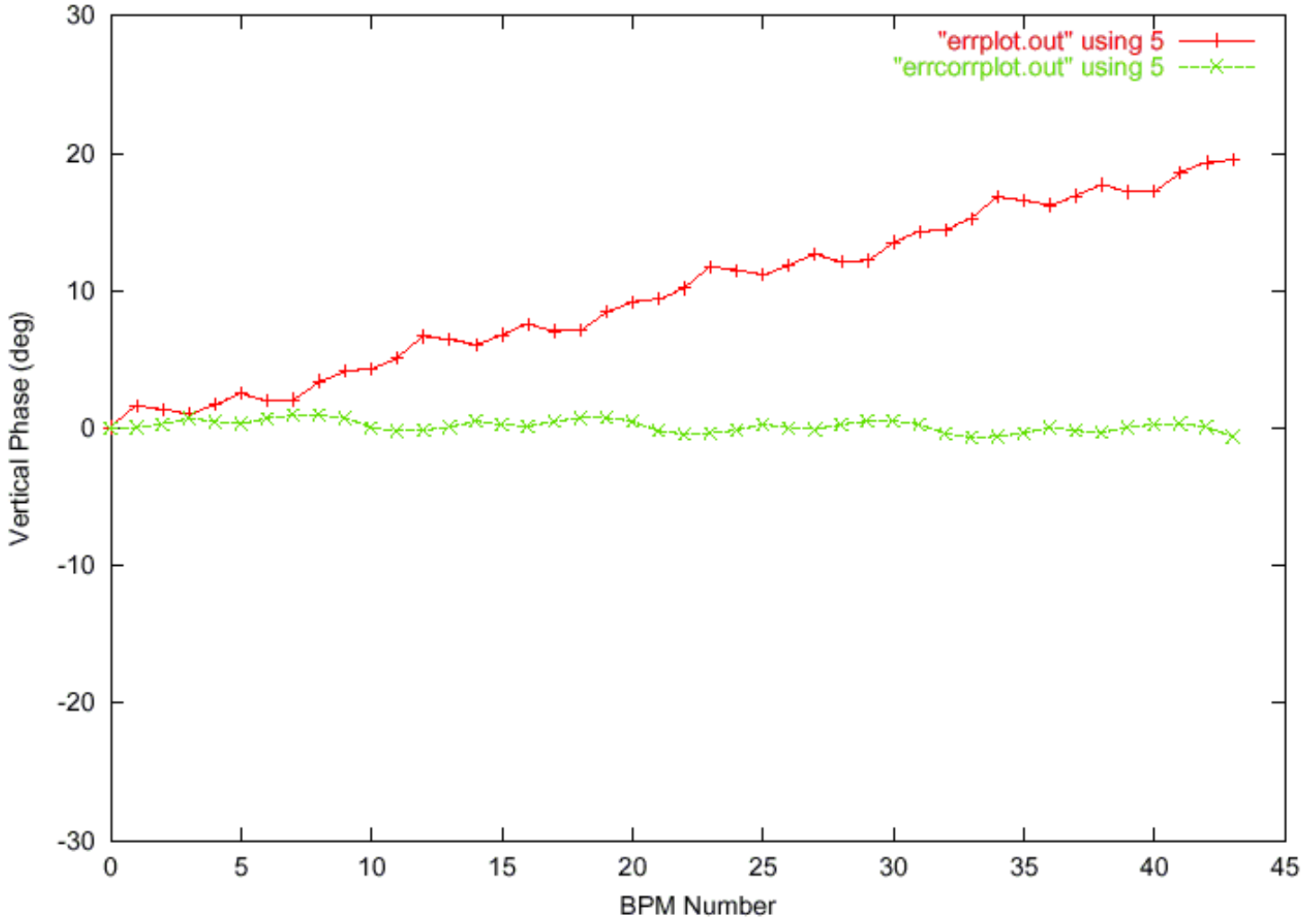


Horizontal Db/b vs. BPM Number

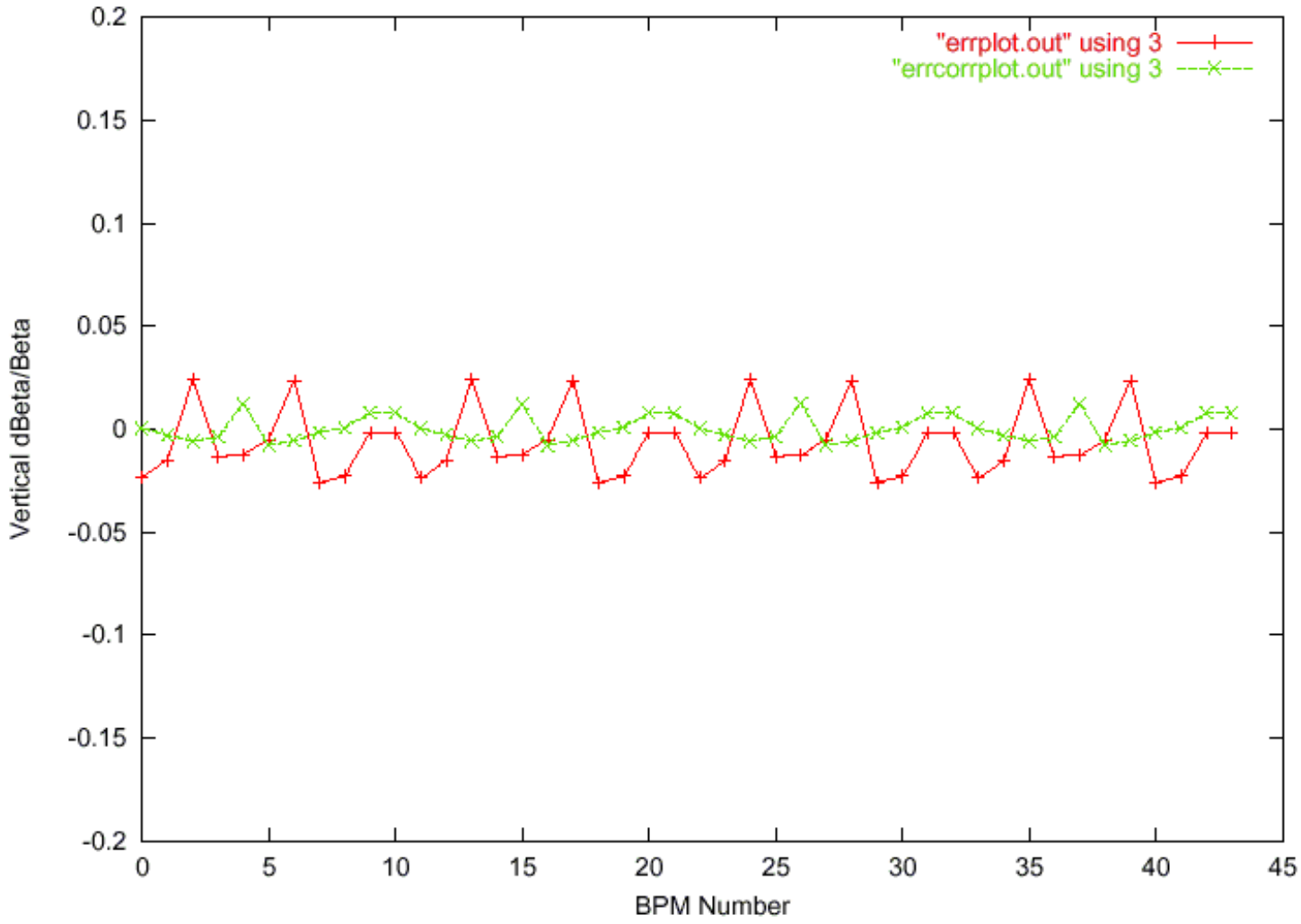


Vertical Betatron Phase Error (degrees)

$Df = f_{meas} - f_{design}$ vs. BPM Number



Vertical Db/b vs. BPM Number



To-do:

- These algorithms work
- Real error study is next on the list
  - Realistic alignment error sets
  - Realistic quadrupole strength error sets
  - BPM measurement errors
  - Understand (quantitatively) phase-measurement capabilities of BPM system
- Incorporate other correction algorithms and compare
  - 3-bump, harmonic correction (orbit)
  - Response-matrix measurement (linear optics)